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(54) **Electrostatically deformographic switches.**

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IBM JOURNAL OF RESEARCH AND DEVELOPMENT, Vol. 23, No. 4, July 1979 New York K.E. PETERSEN "Micromechanical Membrane Switches on Silicon", pages 376 to 385

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Courier Press, Leamington Spa, England.

Description

This invention relates to electrostatically deflectable light switches used in deformographic displays.

Electrostatically deflectable light valves are shown in U.S. Patent 3 746 911 to H. C. Nathanson, et al; U.S. Patent 3 886 310 to J. Guldberg et al; U.S. Patent 3 989 890 to H. C. Nathson, et al; and described in an article entitled "The Mirror-Matrix Tube: A Novel Light Valve for Projection Displays" authored by R. N. Thomas et al, which appeared in the "IEEE Transactions on Electron Devices", Vol. ED-22, 9 Sept. 1975, on pp. 765—775.

The deflectable light valve described in this paper and the above patents requires an electron beam drive and thus a surrounding vacuum atmosphere.

In an article entitled "Dynamic Micromechanics on Silicon" appearing in the "IEEE Trans. Elec. Devices", ED-25, 10 October 1975 on page 1241 and in an article entitled "Micromechanical Membranes on Silicon" appearing in the "IBM Journal of Research and Development", Vol. 23, 4 July 1979, p. 376, K. Peterson described an integrated semiconductor deflectable switch. This switch is effectively a parallel plate capacitor with a voltage being applied to a metal plate on an insulating beam and to the semiconductor substrate supporting the beam such that when the applied voltage exceeds a threshold voltage, the insulating beam will be fully and non-linearly deflected towards the substrate.

However, when these devices designed by Peterson are incorporated in a large array they cannot be effectively addressed unless a dual switching arrangement is used where one of the switches acts as a relay and the other acts on the storage element. These additional relays double the required area and requires extra processing steps to be effective.

U.S. Patent 4,203,128 to H. Guchel et al, describes a device using an electrostatically deformable thin silicon membrane.

U.S. Patent 3,001,447 to M. Ploke, describes an image reproducing device using a thin foil which buckles when heated.

U.S. Patent 3,137,762 to W. Baumgartner et al, discloses a device for amplifying the brightness of an optical image.

EP—A—12243 discloses a display system including a plurality of deflectable elements which can be selectively deflected by the application of a suitable voltage difference between each element and a support structure. The support structure is formed from a semiconductor material. The deflectable elements and all the associated control devices are also formed from semiconductor material. The deflectable elements and the control devices may all be formed from the basic semiconductor material of the support structure by deposition and etching techniques. However, these micromechanical display elements, too, have each associated a control device in the form of a MOSFET transistor, so that the real estate requirements of the wafer are too high being disadvantageous particularly for large array displays. In addition a correspondingly low resolution of the display is to be encountered.

Based upon EP—A—12243 as prior art the invention as claimed is intended to remedy the drawback mentioned above and to improve known devices. It solves the problem of how to design an electrostatically deformographic switching device comprising:

a substrate of p-type semiconductor material,

an n-type epitaxial layer on said substrate,

a p^+-type region disposed between said epitaxial layer and said substrate,

openings in said epitaxial layer extending through said epitaxial layer and exposing said region,

a coating of insulating material disposed over said epitaxial layer and

a beam of said insulating material extending from said coating of insulating material over each one of said openings, and

electrode layers disposed on said beams,

said beams being deflectable under the influence of a voltage exceeding a threshold voltage applied to the electrode layers, and

said openings and beams being arranged in an x-y-array which is addressed by coincident voltages,

by providing a pair of electrodes disposed on said beam, by means coupled to said electrodes for independently applying to each of said electrodes, with respect to said region, a threshold voltage, said threshold voltage being sufficient to create an electrostatic attraction between both of said electrodes and said region sufficient to overcome the bending stresses in said beam when applied to both of said electrodes but insufficient to overcome the bending stress in said beam when applied to only one of said electrodes, the coincident voltages being applied to selected pairs of said electrodes in the x-y-array for deflecting the respective beams and holding them in a deflected state.

The advantage offered by the invention is mainly that a direct drive display is available which does not need either vacuum envelopes or electron beam drives. Furthermore, greater efficiencies can be realized and no refresh is necessary since the switch will operate in a standby condition. Also only two voltage levels above ground, i.e., a write voltage and a standby voltage, are required. The switch will enable copiers to be directly driven by computers.

The ways of carrying out the invention are described in detail below with reference to drawings which illustrate the different embodiments, in which:

Figure 1 is a pictorial partially cross-sectioned view of an embodiment of the invention.

Figure 2 is a cross-sectional view of the device during one stage of its construction.

Figure 3 is a cross-sectional view of the device in its final stage.

Figure 4 is a top view of a different embodiment of the invention.

Figure 5 is a top view of still another embodiment of the invention.

Figure 6 is a top view of still another embodiment of the invention.

Figure 7 is a cross-section of the device of Figure 6 taken along the lines 9—9.

Description of the preferred embodiments

Figure 1 illustrates a partially cross-sectioned, pictorial view of the preferred embodiment of the invention in which the localized stress due to the electrostatic force on the beam is modified by formation of an interdigitated electrode structure on the surface of the beam.

The embodiment shown comprises a body 10 of semiconductor material, such as silicon, having a layer of insulating material, such as silicon oxide, on one surface thereof. A cantilevered beam 12 of this oxide material is formed by cutting a U-shaped trench in the oxide and etching a pit in the silicon body beneath the beam 12. On the surface of the beam there are formed two interdigitated electrodes 14 and 15.

Figure 2 illustrates a sectional view of the device of Figure 1 during one stage of its construction. The body 10 is comprised of a p-type substrate 16 having an epitaxial layer 17 formed thereon with a p+ type region 18, doped with boron to a concentration peak exceeding typically 7×10^{19}, disposed between the epitaxial layer 17 and the substrate 16. Another p-type region 19 is formed in the epitaxial layer 17 through an opening 20 in the oxide layer 11. Once the region 19 is formed so that it extends down from the surface of the epitaxial layer 17 to merge with the p-type region 18, an oxide 11a is regrown in the opening 20. This regrown layer 11a is considerably thinner than the original oxide 11 because of the methods used to regrow such oxides.

Once this oxide regrowth is completed a U-shaped trench 21 is formed in the oxide layer 11 overlying the p-type region 18 with the open end of the U enclosing the region 19. This U-shaped etch defines the oxide beam 12. The pit 13 is formed by introducing a selective anisotropic etchant through the opening 21 so that the silicon body 11 is etched away beneath the beam 12 leaving it in a cantilevered position over the pit 13 (Figure 3). Boron to the described concentration levels is used to limit the amount of vertical etching when anisotropic etchants are used. A metal for forming the electrodes 14 and 15 is then deposited over the surface of the beam and the interdigitated electrodes 14 and 15 defined therein. Because this regrown oxide layer 11a is substantially thinner than the oxide covering the beam 12, it acts as a hinge when the pit 13 extends under it and helps to lower the stress when the beam is deflected under the influence of an electrostatic force developed by biasing the electrodes 14 and 15 with respect to the underlying P region 18. The pit 13, of course, also permits the beam to deflect downwards. When no voltages are applied to the electrodes, it being assumed that the effect of gravity is negligable, the beam 12 experiences no deflection. As the voltage increases, there is some deflection of the beam until the voltage reaches a critical level called the threshold voltage. At this threshold voltage, the electrostatic forces overcome the internal forces of the beam and the beam suddenly snaps down into a fully deflected position with the end of the beam touching the bottom of the pit. Because the beam is formed of an insulating material the electrodes are prevented from touching the bottom of the pit.

If, at any time before this threshold voltage is reached, the voltage is reduced, the beam will return towards its initial position.

However, after the voltage exceeds this threshold level and the beam has snapped into a fully deflected position, the voltage can be reduced below threshold and still maintain the beam in its deflected position. Indeed, before the beam will return to its initial undeflected position, after having been put into a fully deflected position, the applied voltage must fall below a minimum holding voltage which is nearly zero volts. This minimum holding voltage is that voltage at which the electrostatic force falls below the level of the internal stresses in the deflected beam. When this minimum holding is reached the beam will suddenly snap back to its initial zero position.

The position of the beam can be used to store information. Thus the deflected beam can be a "1" and the undeflected beam a "0". The position of the beam is determined by impinging a ray of light normal to the undeflected surface of the beam and placing an optical detector normal to the fully deflected position of the beam. Thus when the beam is in its initial undeflected position the ray of light is reflected back to its source and the detector is dark and thus can represent a zero. When the beam is fully deflected and the ray of light impinges on the deflected end it is reflected, from the beam at an angle to its original path, and becomes diverted toward the detector. This detected beam can represent a "1".

When two interdigitated electrodes are used on the surface of the beam the voltage applied to both electrodes must be equal to the threshold level before the beam will fully deflect. If two different voltages are applied and one is below the threshold level while the other is at the threshold level the beam will not fully deflect.

For example, if we designate that the voltage applied to electrode 14 with respect to the substrate to be Vx and the voltage applied to the electrode 15 with respect to the substrate to be Vy then

at Vx=Vy=0 V
  The beam is flat
at Vx=Threshold Voltage Vy=0 V
  The beam is not fully deflected
at Vx=Threshold Voltage Vy=1/2 Threshold Voltage
  The beam is not fully deflected
at Vx=Vy=Threshold Voltage
  The beam is fully deflected

Once the beam is deflected, the voltages on both of the electrodes could be reduced to one-half the threshold voltage and still cause the beam to remain in its deflected position.

Because of the difference in position in the fingers with respect to the end of the beam the threshold for the case where Vy is greater than Vx is smaller than the case where Vy is less than Vx. Since the end most element of the electrode at the distant end, or tip of the beam, is element 15, i.e., Vy produces the greatest force on the beam and thus the most bending movement because for any given voltage the force on the beam is proportional to the square of the reciprocal distance between the electrodes. This bascially says that the minimum holding force on the beam required to keep it in a fully deflected position is a complex function of the voltages of both electrodes and that the voltage should never go to zero but should always be at a standby voltage, somewhat in excess of zero. This standby voltage should be for example about one-half the threshold voltage.

This basically says Vx does not have to be brought to ground to cause the device to switch back to its undeflected position. Thus Vx need only be at threshold or one-half threshold while the other line is tri-state threshold to deflect the device, one-half threshold to hold it fully deflected if previously fully deflected and zero volts to permit the beam to return from a fully deflected position to an undeflected position. This can be better appreciated from the following truth table.

Value of Vx	Value of Vy	Result
0	0	No deflection
V standby	0	slight deflection
0	V standby	slight deflection
V standby	V standby	slight deflection
V threshold	0	slight deflection
0	V threshold	slight deflection
V threshold	V threshold	full deflection
V standby	V threshold	retains full deflection
V threshold	V standby	retains full deflection
V standby	V standby	retains full deflection
V standby	0	released from full deflection

This arrangement of interdigitated electrodes now gives the capability of easily forming an x-y array in any size in which each device can readily and easily be written into and held in a deflected state. Thus the present invention results in an array that can be used as a memory or storage which is twice as dense as was the prior art arrays and which can easily be written with two coincident voltages, i.e., one applied to electrode 14 and the other applied to electrode 15. Also only two voltage levels, i.e., one-half threshold and threshold, above ground or zero volts are required.

By reducing the thickness of the oxide 11a over the diffusion 19 the amount of voltage required for deflection is reduced. Such a reduction in deflection force is also realized by either producing an opening in the beam or by narrowing of the beam at its proximal end, i.e., its juncture with the main oxide layer. Such opening or narrowing reduces the movement of inertia of the beam, thus reducing the level of the necessary deflecting force and the required threshold voltage.

Instead of a rectangular beam as shown in Figure 1, other embodiments can also be made. One such embodiment is shown in Figure 4. This figure 4 depicts a semiconductor body 40 having an oxide layer 41 on the surface thereof. Formed in this oxide layer 41 is a substantially square oxide beam 44 suspended over an etched pit 46 provided in the body 40, by a hinge 45 located on one corner of the beam. The other three corners of the beam are freely cantilevered over the pit 46. Two interdigitated electrodes 42 and 43 are disposed over the beam 44. The electrode 42 is substantially enclosed by the electrode 43. The electrodes 42 and 43 are separated one from the other, over the beam, by a space 47.

This electrostatic deformographic device operates in the same manner as does the device shown in Figure 1. However, in this case the corner 48 of the beam, which is diagonally opposite the hinge 45, is the point of greatest deflection when voltages above the threshold voltage are applied to the electrodes 42 and 43.

When these deformographic devices are arranged in x-y arrays, this corner deflectable device has a distinct advantage over that shown in Figure 1. In this case when the light ray is directed against a deflected corner 48, it will be reflected at an angle of 45° with respect to the lines of the array, thus the possibility of erroneous detection due to noise or inadvertent reflection or diffraction from the periodic array is lessened.

Figure 5 depicts still another embodiment. The device shown in Figure 5 is substantially the same as the device shown in Figure 4. This semiconductor body 50 is covered with an oxide layer 51 which was defined therein a substantially square oxide beam 54 suspended by a corner hinge 55 over a pit 56 etched in the body 50. A first substantially square electrode 52 is disposed over the center of the beam 54 and a second line electrode 53 is formed around the electrode 52 so as to substantially enclose the electrode 52. These electrodes are separated by a space 57. This device operates similar to the device shown in Figure 4 such that when both electrodes 52 and 53 have voltages equal to the threshold voltage of the device, applied there to the corner 58 diagonally opposite the hinge 55 will be deflected downwards into the pit 56. The advantage of this design over the interdigitated design of Figure 4 is that the large area of electrode 52 provides a better target for a ray of light and also eliminates any possibility diffracted energy in the direction of the reflected beam due to alleviating interdigitated fingers as might be realized by use of the design of Figure 4.

Figures 6 and 7 show still another variation of the invention. In this embodiment p-type body 80 has an epitaxial layer 83 formed thereon. In this epitaxial layer there are two p+ regions, 81 and 82. Both of these regions 81 and 82 are generally rectangular in form, are hollow and concentric. The region 81 is buried at the juncture of the body 80 and the epitaxial layer 83 while the outer region 82 extends down from the surface of the epitaxial layer 83 to define an enclosed isolated region 85 of the epitaxial layer which also encloses the region 81. An oxide layer 86 overlies the entire epitaxial layer. Openings 87 and 88 are made in the oxide 86 and define a generally rectangular area of oxide 89. These openings 87 and 88 each overlies approximately one-half of the p+ region 81. It should be noted that the openings 87 and 88 do not meet thus permitting the area 89 of oxide generally enclosed by the opening 87 and 88 to be connected to the main body by oxide bridges 90 and 91. A pit 79 is etched in the epitaxial layer 83 and body 80 beneath the oxide area 89. It should be noted that the pit exposes the p+ region 81. Metal electrodes 92 and 93 are deposited over the oxide area 89. It is to be noted that each electrode extends over a respective bridge 90 and 91 to respective metal lines 94 and 95 leading to respective epitaxial contacts 96 and 97 and off chip to a suitable biasing source. The device operates as follows. A voltage with respect to the substrate 80 is impressed on only one of the electrodes, say for example electrode 92. As the voltage is increased the electrostatic force causes the oxide layer 89 over the pit 79 to rotate around the bridges 90 and 91 such that the electrode 92 goes towards the p+ region 81 and the electrode 93 moves away from the p+ region 81. The enclosed epi pockets at each end are biased at the same potential as their corresponding electrodes thereby preventing lateral movement of the entire beam.

Conversely when the electrode 93 is appropriately biased and electrode 92 is biased below the threshold voltage the oxide layer 89 rotates in the other direction.

Claims

1. An electrostatically deformographing switching device comprising:

a substrate (16) of p-type semiconductor material,

an n-type epitaxial layer (17) on said substrate (16),

a p^+ type region (18) disposed between said epitaxial layer (17) and said substrate (16),

openings (13) in said epitaxial layer (17) extending through said epitaxial layer (17) and exposing said region (18),

a coating (11) of insulating material disposed over said epitaxial layer (17), and

a beam (12) of said insulating material extending from said coating (11) of insulating material over each one of said openings (13), and

electrode layers (14, 15) disposed on said beams,

said beams (12) being deflectable under the influence of a voltage exceeding a threshold voltage applied to the electrode layers (14, 15), and

said openings (13) and beams (12) being arranged in an x-y-array which is addressed by coincident voltages,

characterized by a pair of electrodes (14, 15) disposed on said beam (12), by means coupled to said electrodes (14, 15) for independently applying to each of said electrodes (14, 15), with respect to said region (18), a threshold voltage, said threshold voltage being sufficient to create an electrostatic attraction between both of said electrodes (14, 15) and said region (18) sufficient to overcome the bending stresses in said beam (12) when applied to both of said electrodes (14, 15) but insufficient to overcome the bending stress in said beam (12) when applied to only one of said electrodes (14, 15), the coincident voltages being applied to selected pairs of said electrodes (14, 15) in the x-y-array for deflecting the respective beams and holding them in a deflected state.

2. The device as claimed in claim 1, characterized in that said pair of electrodes (14, 15) are interdigitated and alternating down the beam (12) from the proximal end of said beam (12) to the distal end of said beam (12).

3. The device as claimed in claim 1 or claim 2, characterized in that said beam (12) is provided with means at its proximal end for reducing the bending stress in said beam (12).

4. The device as claimed in claim 3, characterized in that said means for reducing the bending stress in the beam (12) comprises a reduction in thickness of the beam (12) at the proximal end of said beam (12).

5. The device as claimed in claim 3, characterized in that said means for reducing the bending stress in the beam (12) comprises a reduction in the width of the beam (12) at its proximal end.

6. A device as claimed in one of the precedent claims, characterized in that said substrate (16), said epitaxial layer (17) as well as said in between region (18) are comprised of silicon and said coating (11) is comprised of silicon dioxide.

7. The device as claimed in one of the precedent claims, characterized in that said beam (12) has a generally square configuration and its proximal end is located at one of the corners of said beam (12) and its distant end is at the corner diagonally opposite to said proximal end.

8. The device as claimed in claim 7 wherein one of said electrodes (14, 15) is square and the other of said electrodes is circumferential to said first electrode.

9. The device as claimed in claims 1 to 8, characterized by a cantilevered beam (12) supported over said substrate (10), and means for reducing said coincident voltages to a standby level sufficient to maintain said deflected beam in said deflected position.

10. The device according to claims 1 to 9, characterized in that said beam (12) is coupled to said coating (11) at two opposing points defining an axis of rotation for said beam (12), so that a threshold voltage sufficient to create an electrostatic attraction between the biased electrode and said region (18) is sufficient to cause said beam (12) to rotate about said axis.

Patentansprüche

1. Elektrostatisches deformographisches Schaltgerät, enthaltend:

ein Substrat (16) aus P-Halbleitermaterial,

eine N-Epitaxieschicht (17) auf dem Substrat (16),

einen P$^+$-Bereich (18) zwischen der Epitaxieschicht (17) und dem Substrat (16),

Öffnungen (13) in der Epitaxieschicht (17), die sich durch die Epitaxieschicht (17) erstrecken und den Bereich (18) freiligen,

eine Isolationsschicht (11) über der Epitaxieschicht (17) und

einen einseitig befestigten Träger (12) aus dem Isoliermaterial, welcher sich von der Isolierschicht (11) über jede der Öffnungen (13) erstreckt, und

Elektrodenschichten (14, 15) auf den Trägern,

wobei die Träger (12) durch eine Spannung abgelenkt werden können, die höher ist als eine an die Elektrodenschichten (14, 15) angelegte Schwellspannung, und

wobei die Öffnungen (13) und Träger (12) in einer X-Y-Anordnung vorgesehen sind, die durch koinzidierende Spannungen angesteuert wird,

gekennzeichnet durch zwei Elektroden (14, 15) auf dem Träger (12),

durch mit den Elektroden (14, 15) verbundene Mittel zum unabhängigen Anlegen einer Schwellspannung an jede dieser Elektroden (14, 15), in bezug auf den Bereich (18), wobei diese Schwellspannung ausreicht zum Aufbau einer elektrostatischen Anziehungskraft zwischen beiden Elektroden (14, 15) und dem Bereich (18), die stark genug ist, um die Biegespannung im Träger (12) zu überwinden bei Anwendung auf beide Elektroden (14, 15), die aber nicht stark genug ist, um die Biegespannung im Träger (12) zu überwinden bei Anwendung auf nur eine der beiden Elektroden (14, 15),

wobei die koinzidierenden Spannung auf ausgewählte Paare der Elektroden (14, 15) in der X-Y-Anordnung angewendet werden, um die entsprechenden Träger abzulenken und sie in einem abgelenkten Zustand zu halten.

2. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß die Elektrodenpaare (14, 15) verzahnt sind und sich entlang dem Träger (12) vom vorderen Ende des Trägers zum freien Ende des Trägers (12) abwechseln.

3. Gerät nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß der Träger (12) an seinem vorderen Ende mit Mitteln zur Reduzierung der Biegespannung in diesem Träger (12) versehen ist.

4. Gerät nach Anspruch 3, dadurch gekennzeichnet, daß die Mittel zur Reduzierung der Biegespannung im Träger (12) aus einer reduzierten Dicke des Trägers (12) am vorderen Ende dieses Trägers (12) bestehen.

5. Gerät nach Anspruch 3, dadurch gekennzeichnet, daß die Mittel zur Reduziering der Biegespannung im Träger (12) aus einer Verminderung der Breite des Trägers (12) ein seinem vorderen Ende bestehen.

6. Gerät nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß das Substrat (16), die Epitaxieschicht (17) sowie der dazwischenliegenden Bereich (18) aus Silicium bestehen und daß die Schicht (11) aus Siliciumdioxid besteht.

7. Gerät nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der Träger (12) eine im allgemeinen quadratische Konfiguration aufweist und daß sein nahes Ende an einer der Ecken des Trägers (12) und sein ent-

ferntes Ende an der dem vorderen Ende diagonal entgegengesetzten Ecke ist.

8. Gerät nach Anspruch 7, in welchem eine der Elektroden (14, 15) quadratisch ist und die andere Elektrode die erstere umgibt.

9. Gerät nach den Ansprüchen 1 bis 8, gekennzeichnet durch einen auskragenden Träger (12) über dem Substrat (10) und Mittel zur Reduzierung der koinzidenten Spannungen in einen Bereitschaftszustand, der ausreicht, den ausgelenkten Träger in der ausgelenkten Position zu halten.

10. Gerät nach den Ansprüchen 1 bis 9, dadurch gekennzeichnet, daß der Träger (12) mit dem Überzug (11) an zwei entgegengesetzten Enden verbunden ist, welche eine Drehachse für den Träger (12) darstellen, so daß eine zur Erzeugung einer Anziehungskraft zwischen vorgespannter Elektrode und Bereich (18) ausreichende Schwellspannung hoch genug ist, um eine Verdrehung des Trägers (12) um die Achse zu verursachen.

Revendications

1. Dispositif de commutation à déviation électrostatique, comportant:

- — un substrat (16) en un matériau semiconducteur du type p,
- — une couche épatixiale de type n (17) située sur ledit substrat (16),
- — une région de type p+ (18) située entre ladite couche épitaxiale (17) et ledit substrat (16),
- — des ouvertures (13) ménagées dans ladite couche épitaxiale (17) et s'étendant à travers cette couche et mettant à nu ladite région (18),
- — un revêtement (11) constitué en un matériau isolant disposé au-dessus de ladite couche épitaxiale (17) et
- — une languette (12) formée dudit matériau isolant, s'étendant à partir dudit revêtement (11) en matériau isolant au-dessus de chacune desdites ouvertures (13) et,
- — des couches formant électrodes (14, 15) disposées sur lesdites languettes,
- — lesdites languettes (12) pouvant fléchir sous l'influence d'une tension dépassant une tension de seuil appliquée aux couches formant électrodes (14, 15) et,
- — lesdites ouvertures (13) et les languettes (12) étant disposées selon un réseau x-y, qui est adressé par des tensions coïncidentes,

caractérisé par un couple d'électrodes (14, 15) disposées sur ladite languette (12),

- — par des moyens accouplés auxdites électrodes (14, 15) et servant à appliquer de façon indépendante, à chacune desdites électrodes (14, 15), par rapport à ladite région (18), une tension de seuil, qui est suffisante pour créer entre les deux dites électrodes (14, 15) et ladite région (18), une attraction électrostatique suffisante pour vaincre les contraintes de flexion dans ladite languette (12) lorsqu'elle est appliquée aux deux dites électrodes (14, 15), mais insuffisante pour vaincre la contrainte de flexion dans ladite languette (12) lorsqu'elle est appliquée uniquement à l'une desdites électrodes (14, 15),
- — les tensions coïncidentes étant appliquées à des couples sélectionnés desdites électrodes (14, 15) dans le réseau x-y de manière à fléchir les languettes respectives et les maintenir dans un état fléchi.

2. Dispositif tel que revendiqué dans la revendication 1, caractérisé en ce que lesdits couples d'électrodes (14, 15) sont interdigitées et alternent réciproquement le long de la languette (12) depuis l'extrémité proximale de cette dernière jusqu'à sont extrémité distale.

3. Dispositif tel que revendiqué dans la revendication 1 ou la revendication 2, caractérisé en ce que ladite languette (12) comporte des moyens situés sur son extrémité proximale et servant à réduire la contrainte de flexion dans ladite languette (12).

4. Dispositif tel que revendiqué dans la revendication 3, caractérisé en ce que lesdits moyens servant à réduire la contrainte de flexion dans la languette (12) incluent une réduction de l'épaisseur de la languette (12) au niveau de l'extrémité proximale de cette dernière.

5. Dispositif tel que revendiqué dans la revendication 3, caractérisé en ce que lesdits moyens servant à réduire la contrainte de flexion dans la languette (12) incluent une réduction de la largeur de la languette (12) au niveau de son extrémité proximale.

6. Dispositif tel que revendiqué dans l'une des revendications précédentes, caractérisé en ce que ledit substrat (16), ladite couche épitaxiale (17) ainsi que ladite région intercalaire (18) sont constituées par du silicium et que ledit revêtement (11) est constitué par du bioxyde de silicium.

7. Dispositif tel que revendiqué dans l'une des revendications précédentes, caractérisé en ce que ladite languette (12) possède une configuration de forme générale carrée et que son extrémité proximale est située au niveau de l'un des angles de ladite languette (12) et que son extrémité distale est située au niveau de l'angle opposé en diagonale à ladite extrémité proximale.

8. Dispositif tel que revendiqué dans la revendication 7, dans lequel l'une desdites électrodes (14, 15) est carrée et l'autre desdites électrodes est disposée circonférentiellement autour de ladite première électrode.

9. Dispositif tel que revendiqué dans les revendications 5 à 8, caractérisé par une languette en porte à faux (12) soutenue au-dessus dudit substrat (10), et des moyens servant à réduire lesdites tensions coïncidentes à un niveau de secours suffisant pour maintenir ladite languette fléchie dans ladite position fléchie.

10. Dispositif selon les revendications 1 à 9, caractérisé en ce que ladite languette (12) est accouplée audit revêtement (11) en deux points

opposés définissant un axe de rotation pour ladit elanguette (12), de sorte qu'une tension de seuil suffisante pour créer une attraction électrostatique entre l'électrode polarisée et ladite région (18) est suffisante pour provoquer une rotation de ladite languette (12) autour dudit axe.

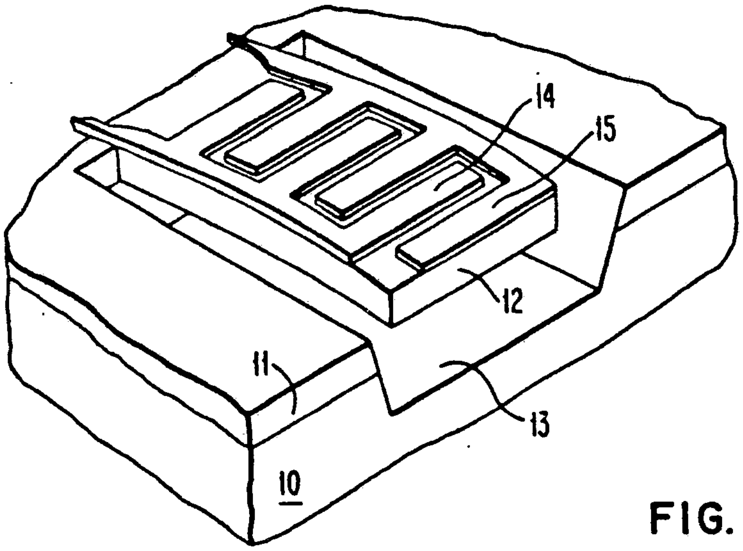

FIG. 1

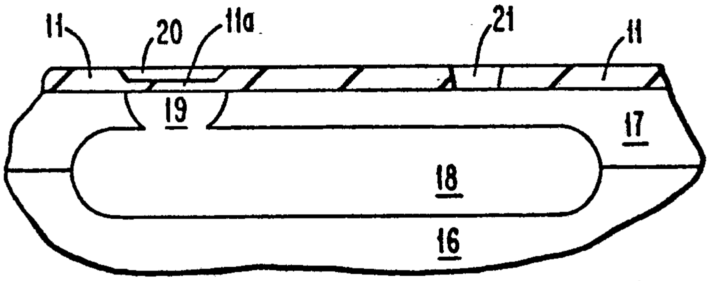

FIG. 2

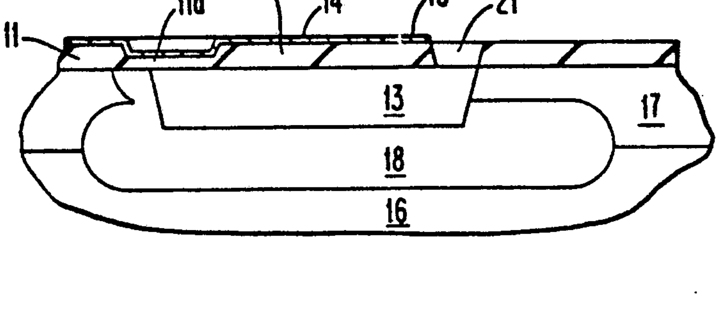

FIG. 3

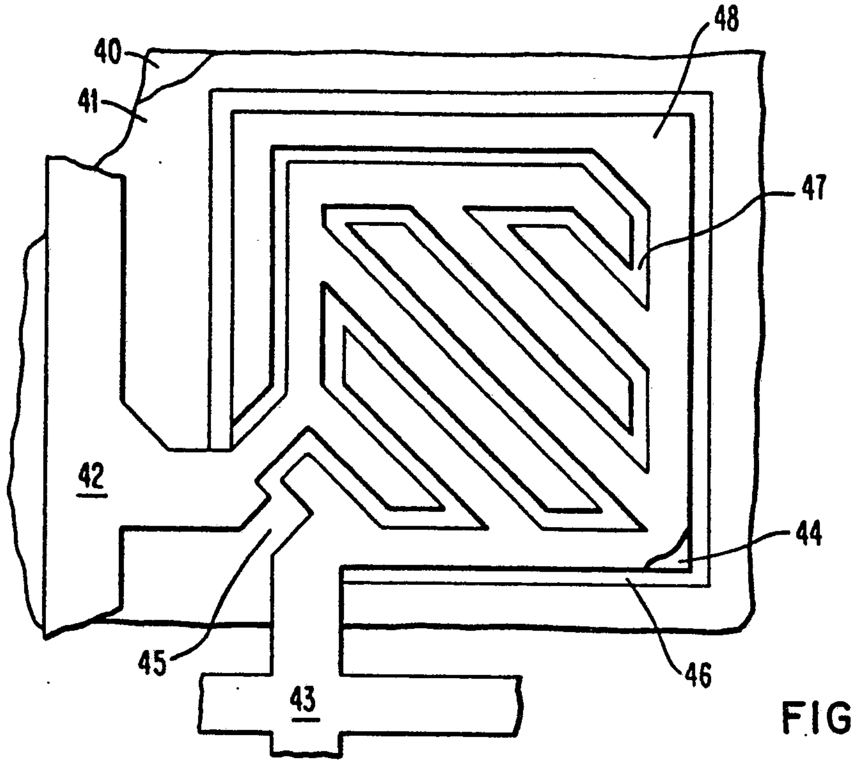

FIG. 4

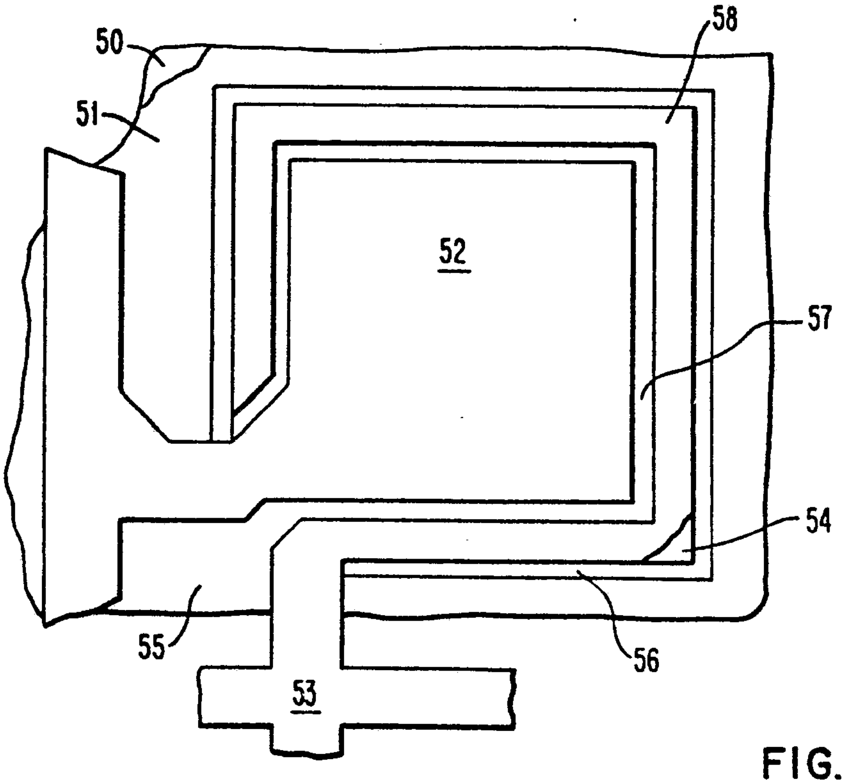

FIG. 5

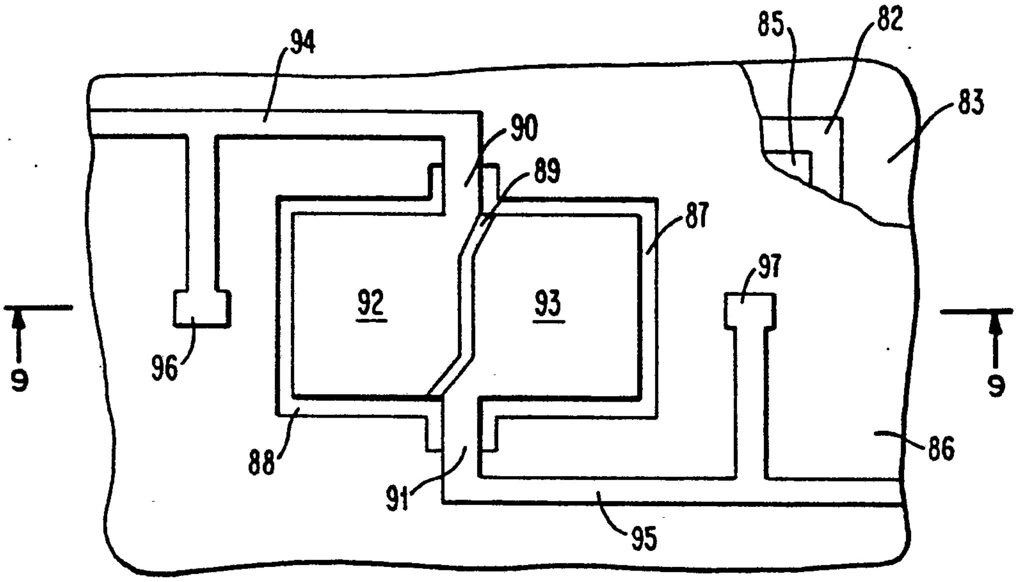
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FIG. 6

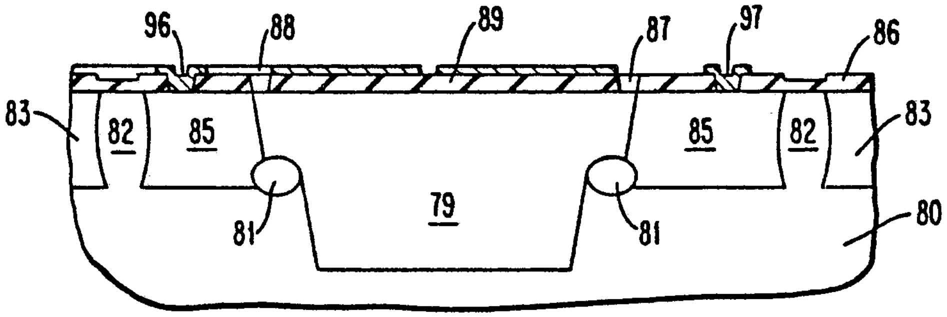
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FIG. 7